

**WL-TR-94-2033**

DEVELOPMENT OF AN ADVANCED JP-8 FUEL

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PREFACE AND ACKNOWLEDGMENTS

This final report describes the technical effort conducted under Air Force Contract No. F33615-90-C-2051, entitled "Development of An Advanced JP-8 Fuel." The technical effort described herein was conducted over a period from August 1990 through January 1993. The research conducted under this contract was administered under the direction of Mr. Steven Anderson, WL/POSF Project Scientist, and Tedd Biddle, P&W Program Manager.

The research conducted under this program was the product of many contributors. Among those who provided guidance and practical experience in pursuit of the program objectives were Steven Anderson, Mel Roquemore, William Harrison, Timothy Edwards, and Robert Morris of WL/POSF. The P&W team which acted as a liaison with the additive manufacturers, compiled the candidate additive inventory, performed screening tests, test method development, and considered the affects of a high-temperature fuel on fuel system components included Tedd Biddle, William Edwards, Earl Hamilton, Toni Massar, Mike Polito, and Richard Sullivan of the P&W Fuels and Lubricants Laboratory; Matt Eder of the F119 Controls Group; and Charlie Graves of the F119 Combustor and Augmentor Group; and Andy Brankovic of the CFD Modeling Group.

Contributors from the University of Dayton Research Institute included Robert Kauffman, Vish Katta, Steven Zabarnic, and Shawn Heneghan. In addition, technical support was provided by Ted Williams, Ed Bins, and Chuck Martel of Systems Research laboratory. Support directed at implementing the Quartz Crystal Microbalance at P&W for monitoring fuel deposition rates in real time was provided by Elmer Klavetter, Steven Martin, and Leonard Casaus of Sandia National Laboratory. The aforementioned organizations and personnel were instrumental in the successful completion of this program. The diverse mix of disciplines, expertise, and experience provided considerable insight into reaction mechanisms and kinetics of deposit formation, CFD modeling, test method development, additive chemistry, and implementation of experimental approaches for determining the propensity of fuels and additives to oxidize and to form deposits and bulk fuel insolubles in static and flowing systems.

1.0 SUMMARY

Technical effort was directed at increasing the design limit of current JP-8 fuel from 325°F (163°C) to 425°F (218°C) at the fuel nozzle. The objective was to accomplish this near-term thermal stability goal solely through the use of a fuel soluble additive package. JP-Thermally stable fuel was considered the thermal stability target since it has the high-temperature properties sought from the significantly more economical JP-8 + 100 formulation. The additives were evaluated in an additive-free Jet A considered typical of fuel most likely to be encountered in the field. DuPont JFA-5, currently the only accepted thermally stability improving additive, was considered state of the art and used as a bench mark.

Additive manufacturers were surveyed and solicited for candidate additives that had potential for improving fuel thermal oxidative stability. Test methods were developed and/or refined for use in screening additives. Using the Hot Liquid Process Simulator (HLPS) in conjunction with a LECO Carbon Determinator, 152 additives were screened. Additive performance was ranked based on surface carbon and differential pressure. Additional screening was performed using the Isothermal Corrosion Oxidation Test (ICOT).

Additives screened included oxygen, sulfur, and nitrogen-type antioxidants; dispersants; detergents; metal deactivators; antifoulants; and proprietary thermal stability improvers. Twenty-seven experimental blends comprised of various additive combinations were tested. Five baseline fuels were evaluated. These fuels included POSF 2827 Jet A reference fuel, POSF 2799 JP-Thermally Stable, POSF 2747 Super K-1 kerosene, POSF 2926 Shell Oil Jet A, and POSF 2928 Exxon Jet A with 15% hydrocracked stock. POSF 2827 represented a typical Jet A and was the primary reference fuel in which the additive candidates were blended and evaluated. A number of special investigations were also performed. A detergent/dispersant was identified that approached the thermal stability target.

2.0 INTRODUCTION

Fuel thermal stability has been recognized as a critical limiting factor in the design of advanced engines. Increased heat loads resulting from increases in lubricant and hydraulic fluid operating temperatures and extensive airframe electronics will rely on the cooling capabilities of the fuel. To accommodate these heat loads, engine hardware designers and fuel developers are confronted with developing coke resistant hardware in combination with fuels with greater cooling capacities. Unless more thermally stable fuels are developed, the benefits of programs such as the Integrated High Performance Turbine Engine Technology (IHPTET) initiative will be partially offset by the need for larger recirculating systems to maintain fuel temperatures below their thermal stability limits. Development of high temperature fuels will rely on the availability of precise, analytical tools for characterizing the thermal stability properties of jet fuels and to accurately model the thermal deposition process:

This program focused on the development and demonstration of innovative laboratory-scale techniques, and use of these techniques in the formulation of a near-term advanced JP-8 fuel. The program was directed specifically at development of an advanced JP-8 fuel to meet or exceed near-term fuel thermal oxidative stability goals. Near-term high temperature stability requirements have been identified by Wright Laboratory (WL) as an increase in fuel temperature at the nozzle from 325° to 425°F (163 to 218°C). This has been described in fuel development terms as JP-8 + 100°F fuel. As a prerequisite to JP-8 + 100°F development, unique and innovative laboratory techniques are required for use in screening, evaluation, and study of candidate fuel/additive formulations. The analytical methodologies developed under this program focused on quantification of fuel deposits and compositional changes of candidate fuel formulations under thermal stress.

Program goals were pursued under four interrelated tasks:

- Task I - Development of Techniques For Screening and Evaluating Additives
- Task II - Procurement and Blending of Fuel/Additive Formulations
- Task III - Screening and Evaluation of Candidate Additives
- Task IV - Characterization of Formulations Meeting JP-8 + 100°F Criteria

3.0 RESULTS AND DISCUSSION

Task I - Development of Techniques For Screening and Evaluating Additives

Task I was directed at development, refinement and implementation of new test methods for screening candidate additive formulations and, ultimately, for characterizing the temperature capabilities of an advanced JP-8 fuel meeting the requirements of JP-8 + 100 °F.

Four test methods were developed and evaluated, or existing methods refined, for use in screening additives and baseline fuels. These included the Microthermal Precipitation Test (MTP), Fuel Reactor Test, Hot Liquid Process Simulator (HLPS), and Isothermal Corrosion Oxidation Test (ICOT).

- *Microthermal Precipitation Test*

The impetus for this development effort was the need for a screening test that could discriminate between fuels of varying propensity to produce thermally induced insoluble particulate material in the bulk fuel. The Microthermal Precipitation (MTP) test thermally stresses a 500-milliliter (mL) fuel sample at 300°F (149°C) for three hours. Fuel pretreatment includes a 6-minute air sparge. A constant oxygen supply to the fuel is maintained by way of 200 psig air pressurization. The fuel is continuously stirred throughout the test. Test temperature is based on fuel temperature as opposed to skin temperature.

At the conclusion of the test, three 50-mL and three 100-mL aliquots of the fuel are filtered through an in-line 25-millimeter (mm) Gelman glass filter having a 1-micron nominal pore size. Particulate material suspended in each aliquot is captured on a Gelman glass filter and quantified via carbon burnoff using a LECO RC-412 Carbon Determinator. Results are reported as micrograms of carbon per square centimeter ($\mu\text{g}/\text{cm}^2$).

Test Set Up

The MTP test is a stand-alone system which incorporates a JFTOT fuel reservoir; an aluminum heating mantle; controlling thermocouple; temperature controller; sampling, bypass and purging valves; and a sampling port with an in-line filter for filtering and collecting the sample. A detailed description of the equipment setup is presented in the following paragraphs.

System Pressurization

The fuel reservoir is pressurized with compressed air. Both a pressure relief and an overpressure safety valve are positioned at the top of the reservoir. The overpressure valve was added for safety in case of sudden pressure spikes due to regulator failure or auto ignition. In addition, a shutoff valve isolates the regulator and gauges from the

pressurized fuel reservoir during testing. This safeguards against regulator damage in the event of autoignition. A condensing coil is located between the reservoir and pressure gauge to keep condensing vapors from damaging the gauge mechanism.

Heating And Temperature Control

An aluminum heating mantel and temperature controller unit was custom fabricated by InterAv, Inc. The InterAv power supply and enclosure uses an Omega Series 4000A proportional controller. The accuracy of this controller is $\pm 0.5\%$ full scale and has a 1°F resolution. To improve temperature stability and reduce heat loss, a zirconium (Zr) wool jacket is placed around the heating mantel.

A temperature controlling thermocouple, inserted through the top of the reservoir cover then lowered, mid-point into sample, is used to control fuel temperature. A calibrated type K chromel/alumel thermocouple is used. A stir plate and stir bar is used to ensure uniform temperature throughout the sample.

Filtering and Collection of Sample

A sample collection port is located at the bottom of the fuel reservoir. Sampling is controlled by two valves. A stainless steel, three-way valve directs the sample through a vernier flow control valve to the filter holder, through the Gelman glass filter, and into a graduated cylinder. Placed in the alternate position, the three-way valve reroutes the sample through a stainless steel tube into a collection beaker. In this second valve position, a nonfiltered sample can be obtained or the reservoir drained.

Filtering is accomplished using a 25-mm Gelman borosilicate glass microfiber filter. The Gelman filters used are type A/E containing no organic binders and are autoclavable. The filters are rated at 1022°F (550°C) and have a 1-micron nominal pore size. Lot numbers are maintained for each analysis. The Gelman glass filter is housed in a Millipore micro-syringe 25-mm filter holder which has been modified with a Swagelok fitting. The filter holder is 304 stainless steel. Filtering rate is governed via the vernier valve which is located downstream of the filter holder. In addition, a vernier valve is positioned in line with a vacuum pump to ensure a constant, uniform vacuum rate during the hexane rinse of each filter.

Results

Preliminary test results showed that the MTP had the ability to discriminate between fuels and additives of varying propensity to form bulk fuel insolubles. Appendix B presents a ranking of additives based on the MTP test as well as a master list of all replicate runs performed. The MTP test was ultimately replaced by the Fuel Reactor test due to a requirement to accelerate additive screening. The Fuel Reactor Test is described in the following section.

- *Fuel Reactor Test*

The Fuel Reactor Test was developed to be less labor intensive than the MTP test and permit testing up to four additives simultaneously. Test conditions are similar to those established for the larger-scale MTP test:

- √ *Fuel preparation:* prefiltered through a 10 μ -Millipore filter; 6-minute sparge
- √ *Sample size:* 60 milliliter (mL)
- √ *Reactor vessel:* 75-mL Pyrex glass test tube inserted in a 9 inch X 1 $\frac{1}{4}$ inch O.D. stainless steel bomb
- √ *Thermal stressing:* four-port COS aluminum block heater; 300°F (149°C) for 3 hours; 200 psig air
- √ *No. of tests per series:* four tests performed simultaneously

At the conclusion of the test, the stressed fuel from each bomb is filtered through a 1-micron Gelman glass filter. The filters are analyzed for surface carbon using a LECO RC-412 Carbon Determinator.

Five Fuel Reactors were fabricated. The fuel reactors were basically 9-inch X 1 $\frac{1}{4}$ inch O.D. stainless steel bombs. A two-way valve is used to introduce the desired atmosphere and pressure. Swage-type fittings allow disassembly for cleaning the reactor and loading the test fuel. A 75-milliliter (mL) Pyrex glass test tube is used to prevent contact of the fuel and minimize contact of its vapor with the metal reactor walls. Four reactors can be thermally stressed simultaneously using a four-port Corrosion Oxidation Stability (COS) aluminum-block heater. Optimum test times, temperatures and pressures were determined.

The Fuel Reactor test provides a number of advantages over that of the MTP test. These include smaller sample size, post test filtering of the entire aliquot thermally stressed, less labor intensive and performance of up to four tests simultaneously. Preliminary testing showed that the Fuel Reactor test ranked fuels of varying propensity for thermal precipitation in the same order as the MTP test. Repeatability and discrimination between fuels was as good or better than the MTP test. Appendix C presents a ranking of additives based on the Fuel Reactor test as well as a master list of all replicate runs performed.

- *Hot Liquid Process Simulator Test*

The Hot Liquid Process Simulator (HLPS) was selected as the primary tool for screening additives. A detailed description of the technique and how it was applied in screening candidate thermal stability improving additives is described in "Task III - Screening and Evaluation of Candidate Additives." Further, Task III presents a comprehensive ranking of all reference fuels, additives, and experimental blends based on HLPS test results.

- *Isothermal Corrosion Oxidation Test*

The Isothermal Corrosion Oxidation Test (ICOT) was developed by WL for use in screening additives. Because of its ease of setup and quickly established database at WL, it was implemented at P&W as a tool for monitoring bulk fuel insolubles produced during thermal stressing of fuel/additive formulations. A detailed description of the technique and how it was applied in screening candidate thermal stability improving additives is described in "Task III - Screening and Evaluation of Candidate Additives." Further, Task III presents a comprehensive ranking of all reference fuels, additives, and experimental blends.

- *Quartz Crystal Microbalance*

A Quartz Crystal Microbalance (QCM) developed by Sandia National Laboratories (SNL) demonstrated the ability to monitor deposition rate in real time in a static reactor vessel. As a result of technical discussions at WL and SNL, a QCM was evaluated at P&W and University of Dayton Research Institute (UDRI) for use in screening additives. P&W teamed with SNL and UDRI in test method development for static applications.

Preliminary testing showed the technique to be very promising. The test appears to lend itself to routine analysis. An investigation was conducted directed at evaluating the affect of time, temperature, and atmosphere on test repeatability and differentiation between fuel types and additives. The test has been implemented for use in evaluating additives.

Task II - Procurement and Blending of Fuel/Additive Formulations

One hundred fifty two additives were received from 19 additive manufacturers and distributors for screening. A current inventory showing additive category, manufacturer, blending concentration and chemical description is included in Appendix A at the end of this report.

Task III - Screening and Evaluation of Candidate Additives

- *Hot Liquid Process Simulator Test*

All additives in inventory were screened using the HLPS. A comprehensive HLPS ranking of the reference fuels and additives evaluated is shown in Table 2-1. Figure 2-1 is a graphical representation of the HLPS ranking for the 50 best performing reference fuels and additives. Ranking of the reference fuels and candidate additives is based on surface carbon produced during a 5-hour HLPS test performed at 635°F (335°C) using a 316 series stainless steel JFTOT tube. Where multiple tests were performed, the value shown

is an average of the replicate runs. Appendices A through C present master lists of all replicate HLPS, ICOT, MTP, and Fuel Reactor tests performed.

An "Index of Merit" was applied to the additives evaluated in the HLPS test. The formula was used to identify the most promising additives. These additives will be considered for advancement to a second level of screening. Secondary screening will subject the additives to screening in several fuels, package reformulation and concentration optimization, then onward to larger scale flowing tests such as the Phoenix Rig, Augmentor Rig, and the Extended Duration Test. The Index of Merit considers the baseline fuel in which the additive was evaluated and performance in relation to the JP-TS target. Considered for secondary screening are those additives which show a carbon reduction \geq DuPont JFA-5. JFA-5 is the only thermal stability improving additive approved by military specification. Currently, it is considered state of the art.

- *Isothermal Corrosion Oxidation Test*

In the Isothermal Corrosion Oxidation Test (ICOT), performance of the reference fuels and candidate additives is based on carbon produced during a 5-hour test performed at 356°F (180°C). A 70-mL aliquot of fuel is stressed in a 38-millimeter (mm) OD X 300-mm glass COS tube using a multiport aluminum block heater. A 0.25-inch O.D. X 30-inch glass blower tube bubbles air into the fuel at a rate of 1L/hour. Condenser temperature is 68°F (20°C). At the conclusion of the test, the entire aliquot of fuel is filtered through a 1-micron Gelman glass filter. The blower tube and the filter are rinsed with hexane. The filter is dried in an oven prior to carbon burnoff. A LECO RC-412 Carbon Determinator is used to measure surface carbon formed on the glass blower tube and bulk fuel insolubles collected on the Gelman glass filter.

ICOT were performed on 21 additives. Each additive was tested in duplicate. Priority was placed on testing those additives shown to be most promising in HLPS tests.

Reference and target fuels, along with additives screened to date, are ranked in Table 2-2. These are shown in order of increasing bulk fuel insolubles. Blower tube surface carbon is also shown. The value shown is an average of two to four runs. Appendix A presents a master list of all replicate ICOT tests. Standard deviation and coefficient of variation is included for some tests to give insight into the repeatability exhibited by the ICOT. Statistical analysis shows that the ICOT should be considered as a "ball park" screening test.

TABLE 2-1
HLPS RANKING OF FUELS, ADDITIVES, AND EXPERIMENTAL BLENDS

<i>Product Name</i>	<i>Carbon ($\mu\text{g}/\text{cm}^2$)</i>	<i>Delta P/Time (mm Hg/min.)</i>	<i>Product Name</i>	<i>Carbon ($\mu\text{g}/\text{cm}^2$)</i>	<i>Delta P/Time (mm Hg/min.)</i>
Exxon JP-TS	3		POSF 2942	41	300/240
JP-TS Non-Add. Sp. Blend	5	4/300	POSF 2786, 11 mg/L	44	0/300
AF JP-TS	6	1/300	POSF 2786 + 2856	44	
Super K-1	7	0/300	POSF 2901	44	300/300
POSF 2881 + 2786	9	300/25	POSF 2773	45	4/300
POSF 2843 + 2894	12	5/300	POSF 2742	46	300/90
POSF 2908	13	300/5	POSF 2769	46	300/45
POSF 2881 + 2913	13	255/165	POSF 2941	46	5/300
POSF 2913	15	300/180	POSF 2851	47	300/180
POSF 2881	16	300/6	POSF 2879	47	300/54
POSF 2786 + 25 mg/L 2843	16	19/300	POSF 2924	47	300/90
POSF 2843 +2730	16	5/300	POSF 2910	47	300/40
POSF 2894	16	0/300	POSF 2730, 300 mg/L	48	4/300
Super K-1 + POSF 2904	17		POSF 2786, 50 mg/L	48	
POSF 2904 + 25 mg/L 2843	18	300/30	POSF 2880	48	300/120
POSF 2895	20	2/300	POSF 2741	48	22/300
POSF 2843 + 2904 + 2913	21	8/300	POSF 2884	49	300/94
POSF 2786 + 12 mg/L 2843	22	5/300	POSF 2912	50	176/300
POSF 2843 + 2914	22	300/240	POSF 2996	50	300/23
POSF 2904 + 2851 + 2786	23		POSF 2943	50	0/300
POSF 2843	24	300/20	POSF 2737	51	23/300
POSF 2843 + 2913	24	9/300	POSF 2902	51	300/150
POSF 2926 Shell Oil Jet A	24	5/300	POSF 2946	51	0/300
POSF 2789	24	300/60	POSF 2903	52	300/300
POSF N1	25	300/90	POSF 2730, 5 mg/L	52	1/300
POSF 2904	25	300/40	POSF 2772	53	300/210
POSF 2777	25	300/12	POSF 2733, 5 mg/L	54	0/300
POSF2944	25	300/210	POSF 2763	54	300/210
Jet A-1 Ref. +POSF 2904	26		POSF 2881 + 2914	54	300/33
POSF 2905	26	300/4	POSF 2914	55	4/300
POSF 2780	27	300/30	POSF 2947	55	1/300
POSF 2842	27		POSF 2898	56	300/180
POSF 2739	28	300/150	POSF 2788	56	300/300
POSF 2743	29	7/300	POSF 2938	57	300/145
POSF 2778	32	300/56	POSF 2768	58	300/73
POSF 2786, 100 mg/L	32		POSF 2734	61	120/300
POSF 2949	32	4/300	POSF 2767	63	
POSF 2899	33	300/240	POSF 2841	64	300/45
POSF 2907	33	300/10	POSF 2839	65	
POSF 2854	34		POSF 2868	65	300/60
POSF 2921	34	300/120	POSF 2894 + 2727	65	300/180
POSF 2948	34	300/150	POSF N4	66	238/300
POSF 2911	35	300/39	POSF 2770	66	
POSF 2787	36	300/90	POSF 2945	68	0/300
Exxon Jet A w/ 15% HC Stock	37	256/300	POSF 2760	69	
POSF 2906	37	10/300	POSF 2732	69	7/300
POSF 2733, 300mg/L	37	5/300	POSF 2835	70	300/10
POSF 2950	38	5/300	POSF 2790	71	300/17
POSF 2909	38	300/30	POSF 2870	72	
POSF 2940	38	1/300	POSF 2849	72	4/300
POSF 2856, 25 mg/L	40	300/113	POSF 2845	73	5/300
POSF 2927	40	300/60	POSF 2877	74	300/36
POSF 2939	41	300/153	POSF 2846	75	

Note: The average value is shown for replicate runs
See Appendix A for concentrations

Table continued next page

TABLE 2-1 Continued
HLPS RANKING OF FUELS, ADDITIVES, AND EXPERIMENTAL BLENDS EVALUATED TO DATE

<i>Product Name</i>	<i>Carbon ($\mu\text{g}/\text{cm}^2$)</i>	<i>Delta P/Time (mm Hg/min.)</i>	<i>Product Name</i>	<i>Carbon ($\mu\text{g}/\text{cm}^2$)</i>	<i>Delta P/Time (mm Hg/min.)</i>
POSF 2833	78		POSF 2873	106	
POSF 2856, 100 mg/L	79		POSF 2782	106	
POSF 2756	80		POSF 2735	106	300/60
POSF 2731	82	1/300	POSF 2853	107	
POSF 2785	85	300/70	POSF 2864	107	
POSF 2867	86	300/90	POSF 2952	108	300/150
POSF 2771	86		POSF 2757	108	
POSF 2867	86	300/90	POSF 2775	109	
POSF 2771	86		POSF 2784	112	
POSF 2728	88	8/300	POSF 2783	112	
POSF 2766	88		POSF 2752	113	
POSF 2766	88		POSF 2862	114	
POSF 2838	89	300/30	POSF 2872	117	300/5
POSF 2847	90	5/300	POSF 2844	122	
POSF 2858	90		POSF 2859	123	
POSF 2745	90	0/300	POSF 2758	133	300/20
POSF 2897	91		POSF 2761	136	
POSF 2837	91		POSF 2785	141	
POSF 2764	91		POSF 2726	142	
POSF 2737	93	4/300	POSF 2776	144	
POSF 2736	93	300/120	Jet A-1 Ref. Fuel	152	300/60
POSF 2860	93		POSF 2874	154	300/51
POSF 2754	95		POSF 2951	160	1/300
POSF 2781	96		POSF 2861	163	
POSF 2832	97		POSF 2738	218	300/182
POSF 2836	98	300/60	POSF 2850	227	
POSF 2900	98		POSF 2774	262	
POSF 2751	98		POSF 2848	272	5/300
POSF 2840	98		POSF 2744	288	
POSF 2762	99		POSF 2727	342	300/270
POSF 2878	100	300/36	POSF 2729	386	6/300
POSF 2865	100		POSF 2759	1404	18/300
POSF 2765	101		POSF 2881 + 2759	1504	11/300
POSF 2748	102		POSF 2834	Insoluble	
POSF 2753	104		POSF 2871	Insoluble	
POSF 2869	104		POSF 2866	Insoluble	
POSF 2863	104		POSF 2876	**	300/20
POSF 2883	105		POSF 2855	**	
POSF 2735	106	300/60	POSF 2866	Insoluble	
POSF 2755	106		POSF 2876	**	300/20
POSF 2852	106		POSF 2855	**	
Note: The average value is shown for replicate runs See Appendix A for concentrations			** plugged fuel line		

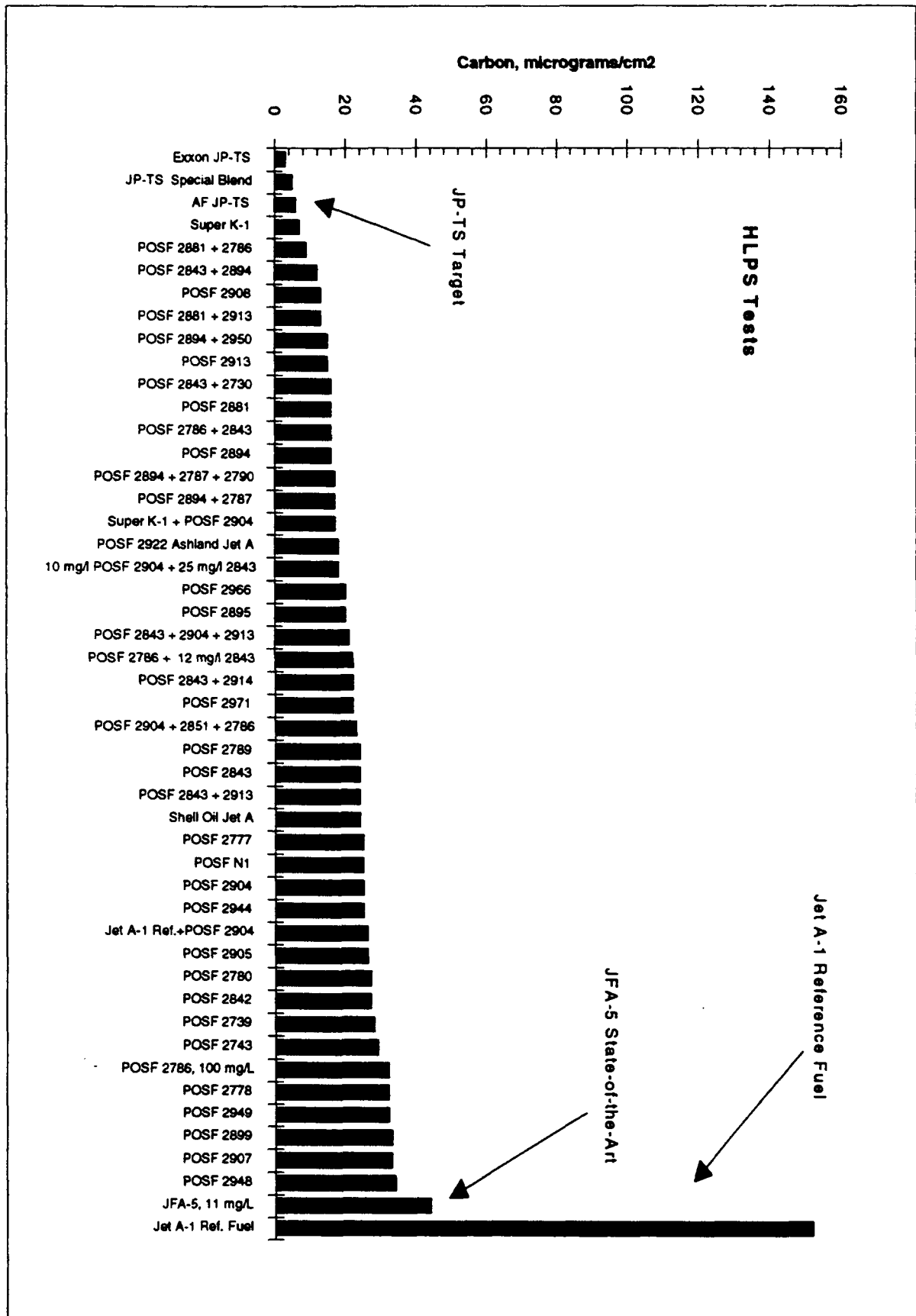


Figure 2-1. HLPs Ranking of the Top 50 Reference Fuels and Additive Blends

**TABLE 2-2
ICOT RANKING OF FUELS, ADDITIVES,
AND EXPERIMENTAL BLENDS**

<i>Sample Name</i>	<i>Filtered Carbon Avg. µg</i>	<i>Blower Tube Carbon Avg. µg</i>	<i>Sample Name</i>	<i>Filtered Carbon Avg. µg</i>	<i>Blower Tube Carbon Avg. µg</i>
POSF 2894	397	590	POSF 2842	1148	567
POSF 2894+ 2727	468	68	POSF 2843	1166	553
POSF 2950	491	99	POSF 2789	1202	721
POSF 2909	494	324	POSF 2777	1204	662
POSF 2739	494	340	POSF 2913	1232	759
POSF 2884	528	564	POSF 2832	1272	12
POSF 2769	529	726	POSF 2951	1288	
JP-TS	584	74	POSF 2949	1320	
POSF N1	598	377	POSF 2741	1388	750
POSF 2880	604	424	POSF 2908	1391	569
POSF 2910	610	567	POSF 2927	1456	351
POSF 2944	650	393	POSF 2849	1457	225
POSF 2733	654	951	POSF 2786	1486	438
POSF 2773	666	721	POSF 2848	1672	468
POSF 2778	747	594	POSF 2901	1675	902
POSF 2787	785	100	POSF 2879	1710	541
POSF 2856, 25 mg/L	836	527	POSF 2847	1768	547
POSF 2907	862	309	Shell Jet A-1	1879	2417
POSF 2780	874	519	POSF 2845	1925	516
POSF 2939	874	505	POSF 2854	2016	562
POSF 2899	877	611	POSF 2895	2055	671
POSF 2856, 100 mg/L	883	707	POSF 2846	2104	605
POSF 2904	891	434	POSF 2952	2221	702
POSF 2786	900	497	POSF 2742	2365	1105
POSF 2948	908	169	POSF 2851	2574	1727
Super K-1	947	97	POSF 2727	2944	113
POSF 2844	1009	2542	Jet A Ref.	2971	3196
POSF 2905	1045	321	POSF 2743	3655	642
POSF 2921	1046	414	POSF 2730	3938	398
Note: See Appendix A for repeatability					

4.0 CONCLUSIONS

Based on HLPS tests, the most promising additives were those that significantly reduced both surface carbon and differential pressure. As shown in Table 2-1, three out of the top four performers were experimental blends that included POSF 2843 antioxidant. The fourth was a detergent/dispersant identified as POSF 2895. Based on ICOT tests, the most promising additives were those that significantly reduced both filtered carbon and blower tube carbon. One experimental blend, POSF 2894 + POSF 2727, and one single additive, POSF 2950, yielded lower filtered carbon than did JP-TS. POSF 2894 + POSF 2727 yielded both lower filtered carbon and blower tube carbon than the JP-TS target.

In addition to the above additives, a number of other candidates have been identified that in combination are expected to further the goal of meeting or exceeding the thermal stability properties of JP-TS. Considerable more work remains in the area of additive screening, experimental blends, test development and interpretation, second-level screening, larger-scale dynamic flowing tests, material compatibility, physical and chemical characterization, and component and engine tests.

The data generated and "lessons learned" during the course of this program have been transitioned to a follow-on Air Force funded effort entitled "An Integrated Approach to Improved Fuel System Design and Fuel Thermal Stability." The aforementioned program will continue the pursuit of the goals and objectives formulated for development and implementation of JP8+100.

5.0 APPENDICES

The following section includes Appendices A through C. Appendix A presents all HLPS and ICOT results; Appendix B all MTP results; and Appendix C all Fuel Reactor test results. Appendix A has been updated to include results compiled subsequent to the end of this technical effort.

APPENDIX A: APPA_FIN.XLS

				HPLS AND ICOT TEST RESULTS								Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HPLS		Blower Tube Carbon, ug	ICOT		Burn Off Date	Burn Off Date	Description / Supplier Recommended Dosage, mg/L		
			mm Hg / Min.	ΔP		Filter Carbon	ug					
91-POSF-2855	25	Plugged	2 hrs into run							AO (N type). Mixed polycycloaliphatic amines / 75 mg/L.		
	100	66	238 in 300							AO (O type). Benzyl alcohol		
91-POSF-2856	100	79			780	923		1/11/93		AO (O type). tert-Butylhydroquinone (TBHQ)		
					634	842						
					707	883		Avg.				
	25	20	300 in 60		462	805		1/11/93				
		57	300 in 60		591	866						
		44	300 in 220		527	836		Avg.				
		Avg. 40										
92-POSF-2899	25	33	300 in 240		603	867		12/10/92		AO (O type). 1-butanone oxime		
					618	886						
					611	877		Avg.				
92-POSF-2897	25	91								AO (O type - vapor phase). 2-butene-1,4-diol		
92-POSF-2900	25	98								AO (O type - vapor phase). Cyclohexanone oxime		
92-POSF-2898	25	56	300 in 180		404	597		2/22/93		AO (O type - vapor phase). 2-cyclohexen-1-one		
					341	413						
					373	505		Avg.				
90-POSF-2751	125	115								Stabilizer/Dispersant. Aliphatic sulfonate substituted aromatic, MDA + color stabilizer. 100-125 mg/L.		
		82										
92-POSF-2895	100	20	2 in 300		569	2180		10/19/92		Detergent/Dispersant. Petromeen AF-114, Proprietary		
					888	2476						
					647	1691						
					581	1871						
					671	2055		Avg.				
92-POSF-2924	10	47	300 in 90		412	690		1/13/93				
					373	609						
					393	650		Avg.				
92-POSF-2901	100	44	300 in 300		879	1780		1/11/93		Proprietary stabilizer		
					924	1570						
					902	1675		Avg.				

APPENDIX A: APPA_FIN.XLS

HPLS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HPLS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter Carbon ug			
92-POSF-2902	10	51	300 in 150		4/10/92	796	1408		2/22/93	Proprietary MDA
						948	1430			
						872	1419	Avg.		
90-POSF-2790	100	71	300 in 17"		10/5/92	541	1856		5/24/93	Proprietary stabilizer (*Line plugged at 150 minutes)
						580	1607			
						561	1632	Avg.		
92-POSF-2903	100	52	300 in 30		8/3/92	442	1019		2/22/93	Proprietary stabilizer
						435	1038			
						439	1029	Avg.		
90-POSF-2787	10	36	300 in 90		4/10/92	101	784		1/11/93	SPEC-AID 8Q400, Proprietary MDA / 6 ppm
						98	785			
						100	785	Avg.		
92-POSF-2894	100	19	0 in 300		8/25/92	474	406		10/6/92	Detergent/Dispersant. (Thermoflo 7R19)
Repeat	100	13	5 in 300		11/4/92	603	413			
	50					542	373			
						741	397			
						590	397	Avg.		
Repeat ICOT						1536	2057		2/22/93	
						972	1914			
						1254	1986	Avg.		
	100					1660	1320		5/25/93	
Repeat ICOT using mass flow controller						2110	942			
						1885	1131	Avg.		
POSF N3	100									Detergent / Dispersant (Thermoflo 7R30)
91-POSF-2858	25	90			12/16/91					AO (O type). 2,2-Bis(4-hydroxyphenyl)butane
91-POSF-2859	25	123			12/16/91					AO (O type). 4-tert-butylcatechol
91-POSF-2860	25	93			11/25/91					AO (O type). 2,5-di-t-butylhydroquinone

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter Carbon ug			
91-POSF-2861	25	163			11/25/91					AO (O type) Hydroquinone monobenzylether
91-POSF-2862	25	114			11/25/91					AO (O type) Hydroquinone monomethyl ether
91-POSF-2863	25	104			12/16/91					AO (O type) 2,2'-methylene bis(6-t-butyl-4-methylphenol)
91-POSF-2864	25	107			12/16/91					AO (O type) 4,4'-methylene bis(2,6-di-t-butylphenol)
91-POSF-2865	25	100			11/8/91					AO (O type) Pentaerythrityl tetra bis(3,5-di-t-butyl-4-hydroxycinnamate)
91-POSF-2866	25	Insoluble								AO (O type) Propyl gallate
91-POSF-2867	25	86	300 in 90		1/17/92					AO (O type) 2,4,6-tris(3,5-di-t-butyl-4-hydroxyphenyl)-mesitylene
91-POSF-2868	25	65	300 in 60		1/17/92					AO (O type) Tris(2-methyl-4-hydroxy-5-t-butylphenyl)butane
91-POSF-2869	25	104			10/10/91					AO (O/S type) 4,4'-Thiobis(2,6-di-t-butylphenol)
91-POSF-2870	25	72			12/16/91					AO (O/N type) 2,6-di-t-butyl-o-dimethylamino-p-cresol
91-POSF-2871	25	Insoluble								AO (O/N type) N-lauroyl-p-aminophenol
91-POSF-2872	25	117	300 in 5		3/3/92					AO (O/N type) 2,4,6-tris(dimethylaminomethyl)phenol
91-POSF-2873	25	106			12/16/91					AO (N type) N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine
91-POSF-2874	25	154			1/17/92					AO (N type) N,N'-bis(1-ethyl-3-methyl-pentyl)-p-phenylene-
92-POSF-2896	25	50	300 in 23		3/3/92	743	906		2/22/93	AO (O/N type) Di-p-methoxydiphenylamine
						941	1372			
						842	1139		Avg.	
91-POSF-2875	25	85	300 in 70		1/17/92					AO (N type) Dioclydiphenylamine ("DODPA")
91-POSF-2876	25	Plugged	300 in 20		1/17/92					AO (N type) N,N'-diphenyl-p-phenylenediamine ("DPPD")
91-POSF-2877	25	74	300 in 36		2/5/92					AO (N type) N,N'-di-2-naphthyl-p-phenylenediamine
91-POSF-2878	25	100	300 in 36		2/5/92					AO (N type) N-phenyl-N'-cyclohexyl-p-phenylenediamine
91-POSF-2879	25	47	300 in 54		1/17/92	618	2300		1/14/93	AO (N type) N-phenyl-1-naphthylamine ("PANA")
						463	1120			
						541	1710		Avg.	
91-POSF-2880	25	48	300 in 120		3/3/92	425	571		1/14/93	AO (N/S type) p-(p-toluenesulfonamide)diphenylamine
						423	637			
						424	604		Avg.	
91-POSF-2881 Repeat	25	16	300 in 2		2/5/92					AO (N type) m-toluylenediamine (toluene-2,4-diamine)
91-POSF-2883	25	16	300 in 10		2/21/92					AO (O/S type) Dilaurylthiodipropionate
91-POSF-2884	25	105	10/30/91		10/30/91					AO (O type) Methylhydroquinone
	25	49	300 in 94		1/17/92	608	575		1/14/93	
						519	481			
						564	528		Avg.	

APPENDIX A: APPA_FIN.XLS

		HLPS AND ICOT TEST RESULTS					Revised 12/02/93	
POSF Number	Conc. mg/L	HLPS		Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
		Carbon ug/cm2	ΔP mm Hg / Min.					
90-POSF-2741	300	48	22 in 300	8/25/92	702	1312	1/13/93	Detergent / Dispersant for diesel fuel. 1500 mg/L
					797	1463		
					750	1388	Avg.	
90-POSF-2742	25	46	300 in 90	10/5/92	1261	2542	1/11/93	Antioxidant Package for diesel fuel. 50 mg/L
					948	2188		
					1105	2365	Avg.	
90-POSF-2743	300	29	7 in 300	10/5/92	635	3548	12/9/92	Detergent / Dispersant for diesel fuel. 1500 mg/L
					649	3761		
					642	3555	Avg.	
90-POSF-2744 Drum #2	1000	288		6/18/91				Detergent/Dispersant for gasolines. 1500 mg/L
	300	68	6 in 300	10/15/92				
90-POSF-2745	300	90	0 in 300	10/5/92				Detergent/Dispersant for gasolines. 1500 mg/L
92-POSF-2927 Repeat	25	43	300 in 94	6/11/92	370	1433	1/11/93	AO (N type). N,N'-di-isopropyl-p-phenylene diamine
		36	300 in 25	6/26/92	331	1478		
		Avg: 40			351	1456	Avg.	
91-POSF-2851 Repeat	25	120		10/18/91	1647	2585	1/11/93	AO (O type). 2,6-di-t-butyl-4-methylphenol (BHT, IONOL) / 16 - 32 mg/L
		47	300 in 180	6/11/92	1807	2562		
					1727	2574	Avg.	
92-POSF-2912	5	50	176 in 300	6/3/92	281	902	2/22/93	Proprietary Dispersant (Methacrylate type) / 5 mg/L
					383	967		
					332	935	Avg.	
92-POSF-2913	5	15	300 in 180	3/27/92	697	1603	12/9/92	Proprietary Dispersant (Styrene monomer) / 5 mg/L
					821	861		
					759	1232	Avg.	
Repeat	5				384	1141	2/24/93	
					414	1084		
					399	1113	Avg.	

APPENDIX A: APPA_FIN.XLS

		HLPS AND ICOT TEST RESULTS										Revised 12/02/93	
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L			
			ΔP mm Hg / Min.				Filler Carbon ug						
92-POSF-2914	5	55	4 in 300		5/29/92	462	892		2/24/93	Proprietary Dispersant / 5 mg/L			
						515	819						
						489	856		Avg.				
90-POSF-2786	11	49	0 in 300		6/15/91	288	867		10/5/92	AO/Disp./MDA. Prop. comp. / methacrylate polymer + MDA. / 12 mg/L.			
		47			6/17/91	511	925						
		49			6/20/91	576	927						
		40			7/15/91	613	882						
		33			7/15/91	497	900		Avg.				
		37			7/15/91	146	30		S.D.				
	11	29	0 in 300		6/26/92	929	1182		5/20/93	Duplicate HLPS tests performed by two different operators on the same day.			
	11	30	0 in 300		6/26/92	795	1070						
						862	1126		Avg.				
	50	40			9/11/91	546	1297		1/13/93				
		57			9/11/91	330	1674						
		Avg: 49				438	1486		Avg.				
	100	36			9/11/91								
		29			9/11/91								
POSF N1	10	25	300 in 90		3/27/92	355	596		12/8/92	Same as MDA / 5.8 ppm Max.			
						398	599						
						377	598		Avg.				
92-POSF-2904	10	26			11/8/91								
92-POSF-2905	10	24	300 in 4		4/15/92	306	1084		12/8/92	MDA. N,N'-disalicylidene-1,2-diaminocyclohexane & solvent. 5.8 mg/L.			
						335	1006						
						321	1045		Avg.				
	10	28	300 in 5		4/24/92								
92-POSF-2904	10	25	300 in 40		4/3/92	409	899		12/8/92	MDA. N,N'-disalicylidene-1,2-propanediamine & solvent. / 5.8 mg/L.			
						459	883						
						434	891		Avg.				
91-POSF-2852	25	106			10/18/91					AO (N type). Organic Amines / 60 mg/L.			

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.	Filter Carbon ug						
91-POSF-2853	25	107			10/18/91					AO (N type). Amino Amide / 100 mg/L.
91-POSF-2854	25	34			10/18/91	601	2081		12/11/92	AO/MDA. Organic Amines + Metal deactivator. 64 mg/L
Repeat	50	45	300 in 210		10/5/92	522	1951			Repeat test to evaluate at supplier recommended dosage.
						562	2016		Avg.	
92-POSF-2906	25	33	1 in 300		5/1/92	607	794		12/16/92	Same as JFA-5, except different dispersant
Repeat	25	41	18 in 300		6/26/92	483	889			
						545	842		Avg.	
92-POSF-2907	25	33	300 in 10		5/1/92	290	881		12/11/92	Similar to JFA-5, except different AO and dispersant
						328	843			
						309	862		Avg.	
92-POSF-2908	25	13	300 in 5		5/1/92	575	1238			Same as JFA-5, except different dispersant
						439	1181			
						666	1569			
						596	1576			
						569	1391		Avg.	
92-POSF-2909	25	38	300 in 30		5/1/92	315	473		1/11/93	Similar to JFA-5, except different AO and Dispersant
						333	514			
						324	494		Avg.	
92-POSF-2910	25	47	300 in 40		5/1/92	434	621		1/13/93	Two different AO types + DMD @ 40% found in JFA-5
						700	599			
						567	610		Avg.	
92-POSF-2911	25	35	300 in 39		5/1/92	616	877		12/16/92	Three different AOs + DMD @ 60% found in JFA-5
						535	923			
						576	900		Avg.	
92-POSF-2921	25	35	300 in 120		5/1/92	448	936		12/11/92	Different from JFA-5: Proprietary
						380	1156			
						414	1046		Avg.	

APPENDIX A: APPA_FIN.XLS

		HLPS AND ICOT TEST RESULTS						Revised 12/02/93	
POSF Number	Conc. mg/L	HLPS		ICOT		Blower Tube Carbon, ug	Filter Carbon, ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
		Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Burn Off Date				
POSF N5	25								AO in JFA-5 (Amino Amide)
93-POSF-2988	15								New JFA-5
90-POSF-2748	200	102		6/20/91					Stabilizer / extender. *Animal and vegetable fats* ?!
90-POSF-2758	100	133	300 in 20	8/25/92					Detergent / Dispersant. Imidazoline, substituted fatty
90-POSF-2752	25	113		10/30/91					AO (O type). 98% 2,6-di-t-butylphenol + others. 24 mg/L
90-POSF-2753	25	104		6/20/91					AO (O/N type). 98% min. 2,6-di-t-butyl- alpha -dimethylamino-
90-POSF-2754	25	95		10/10/91					AO (O type). 97.5% 4,4'-methylene-bis(2,6-di-t-butyl-
90-POSF-2757	25	108		11/25/91					AO (O type). Mixture of t-butylphenols. / 24 mg/L
90-POSF-2755	25	106		12/16/91					AO (O type). Mixture of t-butylphenols. 24 mg/L
90-POSF-2756	25	80		11/15/91					AO (O type). 2,6-di-t-butylphenol + solvent. 24 mg/L
91-POSF-2832	25	97		11/25/91		1134	1378	12/7/92	AO (N type). Aromatic amine
						1349	1165		
						1242	1272	Avg.	
91-POSF-2833	25	78		10/10/91					AO (O/S type). Thioamine
91-POSF-2834	25	Insoluble							AO (N type). Aromatic amine
91-POSF-2835	25	70	300 in 10	2/5/92					AO (N type). Aromatic amine
91-POSF-2836	25	98	300 in 60	2/5/92					AO (N type). Aromatic amine
91-POSF-2837	25	91		12/16/91					AO (N type). Aromatic amine
91-POSF-2838	25	93	300 in 30	2/5/92					AO (N type). Aromatic amine
Repeat		85	300 in 75	2/5/92					AO (N type). Aromatic amine
91-POSF-2839	25	65		11/6/91					AO (N type). Aliphatic amine
91-POSF-2840	25	98		10/30/91					AO (N type). Aromatic amine
91-POSF-2841	25	173		10/18/91					AO (N/O type). Amino ether
Repeat		64	300 in 60	2/21/92					
Repeat		64	300 in 60	3/3/92					
91-POSF-2842	25	27		10/18/91		347	1162	12/7/92	AO (O type). Phenol
		50	3 in 300	3/27/92		787	1134		
		25	300 in 14	4/3/92		567	1148	Avg.	
		Avg. 34							
91-POSF-2843	25	24	300 in 20	11/15/91		567	1082	11/4/92	AO (O type). Phenol

APPENDIX A: APPA_FIN.XLS

HPLS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HPLS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter	Carbon ug		
						482		1256		
						611		1126		
						550		1198		
						553		1166	Avg	
91-POSF-2844	25	122		11/25/91		2470		932	11/4/92	AO (O type). Phenol
						2476		1230		
						2549		960		
						2673		914		
						2542		1009	Avg	
91-POSF-2845	100	73	1 in 300	8/3/92		531		1999	10/19/92	Low MW detergent + high MW N2 dispersant + AO & sol.
						582		2087		
						464		1868		
						486		1748		
						516		1925	Avg	
91-POSF-2846	100	75		10/10/91		468		2105	10/20/92	Low MW detergent + high MW N2 dispersant + AO & sol.
						652		2073		
						693		2140		
						605		2097		
						605		2104	Avg	
91-POSF-2847	100	90	0 in 300	8/3/92		552		2225	10/20/92	Low MW deterg. + high MW N2 disp. + AO & sol. oil.
						326*		1393		
						750		1687		* Deposit "ring" came off blower tube and onto filter during hexane rinse.
						559		1765		
						547		1768	Avg	
91-POSF-2848	100	272	0 in 300	8/3/92		416		1590	12/7/92	Low MW deterg. + high MW N2 disp. + AO & solvent.
						519		1754		
						468		1672	Avg.	
91-POSF-2849	100	72	0 in 300	8/3/92		189		1071	12/7/92	Low MW deterg. + high MW N2 disp. + AO & solvent.
						260		1842		
						225		1457	Avg.	

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HLPS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter Carbon ug			
POSF N2	100	69	300 in 100	6/2/93						30% 2, 2'-Bypridyl, 60% 1-Methyl-2 Pyrrolidinone & 10% Dipropylene Glycol
90-POSF-2759	1000	1404	18 in 300	5/29/92						Disp. 1-Hydroxyethyl-2-heptadecenyl imidazoline. 1000 mg/L.
90-POSF-2785	25	141		7/15/91						Deterg. / Disp. Alkylphenol/formaldehyde resin/ aromatic
91-POSF-2850	50	227		10/10/91						naphtha and large chain alkylphenol/naphthalene/trimethyl-
	80	53		7/15/91						benzene. / 80 mg/L.
		130*	(Flow slowed	8/14/91						
		106*	- cause unk.	8/14/91						
90-POSF-2766	25	88		12/16/91						AO (O type). MOBILAD C145, Alkyl phenol / 25 mg/L.
90-POSF-2767	25	63		10/18/91						AO (n type). MOBILAD C146, Aryl Amine. / 50 mg/L.
90-POSF-2726	1000	142		6/15/91						Detergent / Dispersant. Proprietary. 1500 mg/L.
90-POSF-2760	25	69		10/18/91						AO (O type). Alkyl phenol / 25 mg/L.
90-POSF-2727	300	342	300 in 270	7/10/92		IGNITED	2742			Detergent. Proprietary / 1500 mg/L.
						104	3010			
						130	3012			
						104	3011			
						113	2944	Avg		
90-POSF-2761	25	136		6/17/91						AO (N type). Aryl amine / 50 mg/L.
90-POSF-2762	25	99		11/8/91						AO (O type). Alkyl phenol / 25 mg/L.
92-POSF-2938	600	57	300 in 145	12/10/92						AO (O type). Alkyl Phenol / 570 to 856 mg/L
90-POSF-2733	300	37	5 in 300	7/10/92		641	644		1/11/93	Detergent, Proprietary / 1500 mg/L.
	5	54	0 in 300	8/14/92		1260	663			
						951	654	Avg.		
	300					213	347		2/22/93	Ref. Fuel Drum #3 fuel used.
						276	448			
						245	398	Avg.		
Repeat ICOT using mass flow controller										
	300					1220	467		5/25/93	
						1200	295			
						1210	381	Avg.		

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS										Revised 12/02/93
			HLPS				ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug		Burn Off Date	Description / Supplier Recommended Dosage, mg/L	
92-POSF-2939	600	41	300 in 153	12/10/92	479	898		12/8/92	Experimental, Ether Ester / 570 to 856 mg/L (Clog Buster)	
					531	850				
					505	874		Avg.		
90-POSF-2763	25	37		10/30/91	403	845		2/24/93	AO (O type). Aryl phenol / 25 mg/L.	
Repeat	25	72	300 in 210	8/3/92	352	639				
					378	742		Avg.		
93-POSF-2970	25	50	300 in 120	3/12/93	1376	1235		5/24/93	Experimental alkylated phenol	
					1606	966				
					1491	1101		Avg.		
93-POSF-2971	25	22	300 in 60	3/12/93	396	1777		5/24/93	Experimental alkylated phenol	
					305	1710				
					351	1744		Avg.		
90-POSF-2734	300	61	120 in 300	7/10/92					Detergent, Proprietary / 1500 mg/L.	
90-POSF-2764	25	91		12/16/91					AO (N type). Aryl amine / 50 mg/L.	
90-POSF-2735	1000	106	300 in 60	5/29/92					Detergent, Proprietary / 1500 Mg/L.	
90-POSF-2732	300	69	7 in 300	7/10/92					Detergent, Proprietary / 1500 mg/L.	
90-POSF-2765	25	101		11/8/91					AO (N type). Aryl amine / 50 mg/L.	
93-POSF-2972	25	55	300 in 150,	3/12/93	448	1153		5/24/93	Experimental alkylated triazole	
					459	1280				
					454	1217		Avg.		
92-POSF-2948	600	34	300 in 150	11/4/92	177	877		12/11/92	AO (O type). Alkyl Phenol / 570 to 856 mg/L	
					161	939				
					169	908		Avg.		
92-POSF-2940	600	38	1 in 300	12/10/92					AO (O type). Alkyl Phenol / 570 to 856 mg/L	
92-POSF-2941	600	46	5 in 300	12/10/92					AO (O type). Alkyl Phenol / 570 to 856 mg/L	
92-POSF-2942	600	41	300 in 240	12/10/92					Dispersant, Ether Succinimide / 570 to 856 mg/L	
92-POSF-2943	600	50	0 in 300	12/10/92					Experimental, Ether Ester / 570 to 856 mg/L (Clog Buster)	
92-POSF-2944	600	25	300 in 210	12/10/92					Arylamine Ester (AO & Detergent in one molecule) 600 mg/L.	
92-POSF-2950	600	38	5 in 300	11/4/92	84	418		1/11/93	Arylamine Ester (AO & Detergent in one molecule) 600mg/L	
					113	563				

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		HPLS AND ICOT TEST RESULTS						Revised 12/02/93	
POSF Number	Conc. mg/L	HPLS		HPLS		ICOT		Description / Supplier Recommended Dosage, mg/L	
		Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filler Carbon ug	Burn Off Date		
Repeat	600	39	0 in 300	3/12/93	360	1900	2/24/93	Ref. Fuel Drum #3 fuel used.	
					621	3009			
					491	2455	Avg.		
Repeat ICOT using mass flow controller	600				232	671	5/25/93		
					234	612			
					233	642	Avg.		
92-POSF-2945	600	68	0 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L	
92-POSF-2949	600	32	4 in 300	11/4/92	112	1550	12/10/92	Ester (AO & Detergent in one molecule) 600mg/L	
					106	1090			
					109	1320	Avg.		
92-POSF-2946	600	51	0 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L	
92-POSF-2947	600	55	1 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L	
93-POSF-2973	300	37	300 in 105	3/12/93	3598	1447	5/24/93	Alkylated Triazole	
					2423	1465			
					3011	1456	Avg.		
93-POSF-2974	25	48	300 in 120	3/12/93	2896	1399	5/24/93	Alkylated Phenol	
					2352	1374			
					2624	1387	Avg.		
93-POSF-2989	25	67	12 in 300	6/16/93	1010	1350	6/2/93	AO, N Type) Alkylated naphthylamine (NEW 4/93)	
					*	1240		* Tube shattered when cut.	
						1295	Avg.		
Repeat with new mass flow controller									
					1160	1290	6/16/93		
					1280	903			
					1220	1097	Avg.		
90-POSF-2730	300	48	4 in 300	7/10/92	405	4183	1/12/93	Detergents, Proprietary / 1500 mg/L	
	5	52	1 in 300	8/14/92	391	3692			
					398	3938	Avg.		

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HLPS AND ICOT TEST RESULTS										Revised 12/02/93
			HLPS				ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L		
Repeat										
					253	3270	2/22/93			
					324	3215				
					289	3243	Avg.			
90-POSF-2729	300	386	2 in 300	7/10/92				Detergents, Proprietary / 1500 mg/L.		
Repeat	300	367	6 in 300	8/14/92						
90-POSF-2731	300	46	Line clogged	7/10/92				Detergents, Proprietary / 1500 mg/L.		
Repeat	300	82	1 in 300	8/14/92						
90-POSF-2728	300	88	5 in 300	7/10/92				Detergents, Proprietary / 1500 mg/L.		
90-POSF-2789	25	24	300 in 60	8/25/92	670	1242	12/10/92	AO/Disp./Stab. Amine substituted resin + aliphatic amine. / 85 - 130 mg/L.		
					772	1161				
					721	1202	Avg.			
90-POSF-2768	100	58	300 in 73	10/5/92				Antifoulant. An alkyl aryl diamine. / 100 mg/L.		
90-POSF-2769	100	46	300 in 45	10/5/92	873	559	1/11/93	Antifoul. An alkyl aryl diamine in heavy aro. naphtha. / 100		
					579	498				
					726	529	Avg.			
90-POSF-2770	100	66		8/14/91				Antifoulant. Substituted amines & butylcatechol in DMF. /100		
90-POSF-2788	100	56	300 in 300	8/3/92	440	2688	2/22/93	Stabilizer. Amine substituted resin. / 85-130 mg/L.		
					542	2602				
					491	2645	Avg.			
90-POSF-2771	11	101		8/26/91				AO/disp. Anhydride / polyamine product + solv. 12mg/L.		
		70		8/26/91						
90-POSF-2772	25	53	300 in 210	8/25/92	734	652	2/22/93	AO / Disp. Imide & acrylate polymer in aro/alcohol. 12mg/L		
					867	811				
					801	732	Avg.			
90-POSF-2773	25	45	0 in 300	8/14/92	659	412	1/11/93	AO / Disp. Amine and acrylic polymers in aro/aliph sol. 12		
					782	920				
					721	666	Avg.			
90-POSF-2774	12	262		6/17/91				AO/Disp./MDA. Amino alkylphenolic resins, amine aldehyde condensate + solvent. 12 mg/L.		
Drum #2	12	38	300 in 63	10/15/92						
90-POSF-2775	11	101		9/11/91				AO/Disp./MDA. Amino alkylphenolic resins, aminealdehyde condensate + solvent. 12 mg/L.		
		117		9/11/91						
90-POSF-2776	12	144		6/15/91				AO/Disp./MDA. Amino alkylphenolic resins, allycyclic		

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HPLS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc mg/L	Carbon ug/cm2	HPLS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Description / Supplier Recommended Dosage, mg/L	
			ΔP mm Hg / Min.				Filter Carbon ug	Burn Off Date		
90-POSF-2777	25	25	300 in 12	8/25/92		561	1118	12/9/92	amine / 12 mg/L	
						763	1289		AO/Disp./MDA. Amino alkylphenolic resins, ethylene diamine. / 12 mg/L	
						662	1204	Avg		
90-POSF-2778	25	32	300 in 56	8/25/92		611	847	12/10/92	AO/Disp./MDA. Amino alkylphenolic resins, N heterocycle derivatives. / 12 mg/L	
						576	646			
						594	747	Avg		
93-POSF-2968	25	40	4 in 300	4/2/93		1271	1672	5/24/93	Experimental dispersant	
						1295	1653			
						1283	1663	Avg		
90-POSF-2737	1000	51	23 in 300	5/29/92					Disp. Anhydride polyamine reaction product in sol. 1000 mg/L	
	300	93	4 in 300	6/26/92		117	467	2/22/93		
						22 (?)	471			
Repeat ICOT using mass flow controller							469	Avg		
	300									
						103	3580	5/25/93		
						100	4060			
						102	3820	Avg		
90-POSF-2738	1000	218	300 in 182	5/29/92					Dispersant. Anhydride/polyamine reaction products in sol.	
90-POSF-2739	300	28	300 in 150	8/14/92		334	505	12/8/92	Disp. Hi MW imide/aminoalkylphenolic resin/acrylic polymer	
						345	482			
						340	494	Avg		
90-POSF-2736	1000	93	300 in 120	5/29/92					Disp. Alkylaryl sulfonates in aromatic solvent. / 1000 mg/L	
93-POSF-2966	300	20	5 in 300	4/2/93		320	1268	5/24/93	Experimental dispersant	
						392	1160			
						356	1214	Avg		
93-POSF-2975	25	44	7 in 300	3/12/93		1998	1181	5/24/93	Experimental antifoulant	
						1312	1247			
						1655	1214	Avg		
93-POSF-2967	25	128	300 in 240	4/2/93		459	1083	5/24/93	Experimental antifoulant	
						453	1117			
						456	1100	Avg		

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			HLPS AND ICOT TEST RESULTS									Revised 12/02/93
			HLPS					ICOT				
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon,ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L				
93-POSF-2957	100	85	300 in 110	7/14/93				Detergent/corrosion inhib. Fatty acid amide acid, mixed alkyl alcohols and fatty diamines in dewaxed heavy paraffinic petroleum distillates.				
93-POSF-2958	100	42	0 in 300	7/14/93				Detergent/corrosion inhib./demulsifier. Alkenyl succinimide & kerosene in dewaxed heavy paraffinic petroleum distillates.				
90-POSF-2781	25	96		10/30/91				AO (N type). 100% N,N'-di-sec-butyl-p-phenylenediamine + solvent. / 2 - 60 mg/L.				
90-POSF-2782	25	106		12/16/91				AO (N type). N-phenyl-N'-sec-butyl-p-phenylenediamine + solvent. / 1 -40 mg/L.				
90-POSF-2783	25	112		12/16/91				AO (N type). UOP No. 12P + N,N'-di-sec-butyl-o-phenylene-diamine + solvent. / 2 - 40 mg/L.				
92-POSF-2951	25	160	1 in 300	8/25/92	115	1287	1/14/93	Dispersant. High molecular weight amine polymer / 25 mg/L				
					667	1288						
					391	1288	Avg.					
92-POSF-2952	25	99	300 in 180	8/14/92	629	2372	1/11/93	AO/Disp. Polyamino polyol in aromatic solvent. / 25 mg/L				
Repeat	25	116	300 in 120	8/14/92	774	2069						
					702	2221	Avg.					
90-POSF-2784	25	112		10/18/91				AO (O type). 100% mixed tertiary butylphenols / 4-50 mg/L.				
90-POSF-2780	10	27	300 in 30	4/10/92	621	873	12/9/92	MDA, N,N'-disalicylidene-1,2-propanediamine & solvent. / 4-16				
					416	875						
					519	874	Avg.					
REFERENCE FUELS												
POSF-2799, JP-TS, A F supplied			HLPS Break Point = 750°F (398.9°C)									
		6		9/27/91	65	586	9/1/92					
		7	1 in 300	2/21/92	61	669	10/5/92					
	Avg:	7			84	474						
					84	607						
					74	584	Avg.					
					12	81	S.D.					
					16%	14%	C.V.					

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APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS			Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.							
New HLPS unit		47	300 in 210	2/10/93		945	481			
						1036	782	Avg.		
Drum #3 repeat						2441	1889	5/20/93		
						1654	1660			
						2048	1775	Avg.		
POSF-2827 Break Point on Drum #3: 540°F (282°C)										
POSF 2922, Ashland Jet A, mildly hydrotreated										
		18	6 in 300	4/2/93		8340	23500	5/25/93		
						7390	19600			
						7865	21550	Avg.		
POSF 2926, Shell Oil Jet A										
		24	5 in 300	8/3/92		2638	IGNITED	10/15/92		
Repeat		45	140 in 300	4/2/93		3066	IGNITED			
Repeat		41	0 in 300	4/14/93		1849	IGNITED			
						1821	IGNITED			
						2713	1879			
						2417		Avg.		
POSF 2928, Exxon Jet A with 15% hydrocracked stock.										
		37	256 in 300	8/3/92		7290	4090	5/25/93		
Repeat		36	300 in 180	4/2/93		*	4000			* Tube data missing. ?
							4045	Avg.		
POSF 2934, Alaska JP-8 (JET A50: -50°F freeze pt.)										
		121	300 in 60	6/16/93		863	1950	6/16/93		
						1110	2290			

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		HLPS AND ICOT TEST RESULTS				Revised 12/02/93	
POSF Number	Conc. mg/L	HLPS		ICOT		Description / Supplier Recommended Dosage, mg/L	
		Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	
					987	2120	Avg.
POSF-2936, Cincinnati (high TAN)		Break Point: 530°F (277°C)					
		65	300 in 215	4/15/93	2810	2800	6/2/93
					3100	3300	
					2955	3090	Avg.
POSF-2959, Mobil MEROX Treated		Break Point: 560°F (293°C)					
		113	1 in 300	4/20/93	7580	802	5/25/93
					** (6.5)	1040	** Questionable data.
						921	Avg.
POSF-2963, NAWC T3 Nozzel Fuel (50 ppb Cu)							
		Plugged	>300 in 60	11/11/93			
Retest without reservoir filter		153	>300 in 46	12/2/93			
POSF-2976, 'New' JPTS							
		6	0 in 300	12/2/93			
POSF-2980, Marathon Oil Co. MEROX Treated		Break Point: 550°F (288°C)					
		52	13 in 300	11/11/93			
POSF-2985, JP-5 (High Nitrogen content)							
		127	300 in 30	11/11/93			
Candidate Additive Experimental P&W Blends							
POSF 2881 + 2786	25+11	9	300 in 25	4/3/92			
POSF 2881 + 2786	25+11	9	300 in 7	4/24/92			

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		HLPS AND ICOT TEST RESULTS				Revised 12/02/93			
POSF Number	Conc. mg/L	HLPS		ICOT		Description / Supplier Recommended Dosage, mg/L			
		Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filler Carbon ug	Burn Off Date		
POSF 2881 + 2913	25+5	52	300 in 120	3/27/92					
POSF 2881 + 2913	25+5	11	2 in 300	4/3/92					
POSF 2881 + 2913	25+5	15	165 in 300	4/15/92					
POSF 2881 + 2913	25+5	14	300 in 75	4/24/92					
POSF 2881 + 2913	25+5	11*	6 in 300	5/29/92					* Note: Single batch of blended additives used.
POSF 2881 + 2913	25+5	19*	300 in 270	5/29/92					
POSF 2881 + 2912 **	25 + 5		300 in 11	7/16/92					** Note: No carbon analysis based on delta P result.
POSF 2881 + 2914	25+5	54	300 in 33	6/26/92					
POSF 2881 + 2759	25+1000	1504	11 in 300	5/29/92					
POSF 2843 + 2786	25+11	16	19 in 300	1/17/92					
POSF 2843 + 2786	12+11	22	5 in 300	1/17/92					
POSF 2843 + 2914	25+5	22	300 in 240	4/24/92					
POSF 2843 + 2914	25+5	20	300 in 300	8/3/92					
POSF 2843 + 2904	25+10	18	300 in 30	2/21/92					
POSF 2843 + 2904 + 2913	25+10+5	21	8 in 300	3/11/92					
POSF 2843 + 2913	25+5	27	9 in 300	3/11/92					
POSF 2843 + 2913	25+5	21	1 in 300	4/24/92					
POSF 2843 + 2913	25+5	19	4 in 300	8/3/92					
POSF 2843 + 2912	25+5	10	Line Plug	8/4/92					
POSF 2843 + 2894	25+25	12	5 in 300	11/4/92					Flow stopped 2 hours into run - test terminated.
POSF 2843 + 2730	25+5	16	5 in 300	11/4/92					
POSF 2786 + 2856	11+100	44		9/24/91					
Super K-1 + POSF 2904	10	17		11/15/91					
POSF 2851 + 2904 + 2786	23+10+11	23		11/15/91					
POSF 2894 + 2727	100+300	65	300 in 180	12/10/92	71	431	12/7/92		
					65	505			
					68	468	Avg.		
Repeat	100+300	69	4 in 300	3/12/93	250	393	2/22/93		* Instrument malfunction
					317	*			

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		HLPS AND ICOT TEST RESULTS						Revised 12/02/93	
					</				

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HLPs AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPs			ICOT			Description / Supplier Recommended Dosage, mg/L	
			ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date			
					187		619	Avg.		
POSF 2894+ 2727 + 2904 + 2856										
100+300+10+25		58	5 in 300	3/12/93	41		1052	2/22/93		
					42		1404			
					42		1228	Avg.		
Exper. Conc. Blends from Belz Chemical										
70% POSF 2894 + 30% 2787	100	46	4 in 300	4/2/93	107		1227	5/24/93		
					679		1591			
					?		1409	Avg.		
70% 2894+20% 2787+10% 2790	100	17	96 in 300	4/2/93	869		1367	5/24/93		
					843		1375			
					856		1371	Avg.		
Affect of DuPont 2786 in Reference Fuels										
POSF 2827 Jet A-1 Ref. Fuel + 2786	11	30	0 in 300	6/26/92	929		1182	5/20/93		
					795		1070			
					862		1126	Avg.		
POSF 2926 + 2786	11	36	0 in 300	4/26/93	5240		2550	6/8/93		
					3490		1290			
					4365		1920	Avg.		
POSF 2928 + 2786	11	23	0 in 300	4/26/93	5520		2510	6/8/93		

APPENDIX A: APPA_FIN.XLS

HPLS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HPLS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter Carbon ug			
						5280		2850		
						5400		2680	Avg.	
POSF 2922 + 2786	11	8	0 in 300	4/26/93		4720		13400	6/11/93	
						2990		15600		
						3855		14500	Avg.	
POSF 2934 + 2786	11					669		2230	6/11/93	
						779		1400		
						724		1815	Avg.	
POSF 2936 + 2786	11	29	0 in 300	4/26/93		737		1850	6/3/93	
						866		1830		
						802		1840	Avg.	
POSF 2959 + 2786	11	20	0 in 300	4/26/93		378		279	6/11/93	
						388		303		
						383		291	Avg.	
Affect of POSF 2894 in Reference Fuels										
POSF 2827 Jet A-1 Ref. Fuel + 2894	100	16	2 in 300	Average		1660		1320	1/13/93	
						2110		942		
						1885		1131	Avg.	
POSF 2926 + 2894	100	25	0 in 300	4/14/93		8570		1350	6/8/93	
						7520		1620		
						8045		1485	Avg.	
POSF 2928 + 2894	100	23	0 in 300	4/14/93		5420		2350	6/8/93	
						9120		1820		
						7270		2085	Avg.	

APPENDIX A: APPA_FIN.XLS

		HLPS AND ICOT TEST RESULTS										Revised 12/02/93	
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L			
			ΔP mm Hg / Min.				Filter Carbon ug						
POSF 2922 + 2894	100	14	0 in 300		4/14/93	4140	13800		6/11/93				
						5920	2830						
						5030		Avg.					
POSF 2934 + 2894	100	180	1 in 300		6/16/93	93	2640		6/11/93				
						6050	2040						
							2340	Avg.					
POSF 2936 + 2894	100	32	0 in 300		4/20/93	3140	3550		6/3/93				
						2770	3250						
						2955	3400	Avg.					
POSF 2959 + 2894	100	30	0 in 300		4/20/93	956	301		6/11/93				
						709	276						
						833	289	Avg.					
AFFECT OF JP8+100 CANDIDATE ADDITIVES ON POSF 2827 JET A-1 REF. FUEL CONTAINING ALL REQUIRED AND OPTIONAL MIL. SPEC. ADDITIVES (MSA)*.													
POSF 2827+MSA*													
POSF 2827+MSA + 2894	100												
POSF 2827+MSA+ 2894+ 2843	100+25												
* MSA package components used for these tests:													
Antioxidant (POSF 2851), 24 mg/L.													
Antistatic (DuPont Stadis 450), 150 to 600 pS/m.													
Corrosion Inhibitor (DuPont DCI 4A), 24 ppm.													

HLPS AND ICOT TEST RESULTS										Revised 12/02/93
POSF Number	Conc. mg/L	Carbon ug/cm2	HLPS		Burn Off Date	Blower Tube Carbon, ug	ICOT		Burn Off Date	Description / Supplier Recommended Dosage, mg/L
			ΔP mm Hg / Min.				Filter Carbon ug			
Fuel System icing Inhibitor (Diethylene glycol monomethyl ether), 0.15 volume %.										
SPECIAL INVESTIGATIONS										
POSF-2893, (WL 1/92)										
		6	300 in 285		2/21/92					
		4	4 in 300		3/27/92					
POSF-2827 + Stressed Super K-1: TAN of 0.015		77	300 in 180		7/1/92					
POSF-2827 + Stressed Super K-1: TAN of 0.03		75	300 in 180		7/1/92					
HLPS 17-MICRON FILTER EXPERIMENT										
POSF 2881 + 2913	25+5	12	23 in 300		8/4/92					The 17 micron filter from test #1 was cleaned with trisolvant,
	25+5	10	300 in 1		8/4/92					vacuum flushed in reverse direction to fuel flow and dried prior to use in test #2.
MISC. NOTES:										
1. Candidate additive inventory now numbers 162.										
2. JP-TS is a blend of:										
Isopar H										
Varsol 1 (soddard solvent or mineral spirits), IBP 159C; EP 202C										
LOPS (low odor paraffinic solvent) aka Turbo Fuel A										
3. Additive Incompatibility:										
POSF 2871 must be heated to get into solution; over night drops out of solution. Hazy swirls.										
POSF 2855 plugged filter 2 hours into test.										
POSF 2866 Unable to get into solution after heating at 120°F and stirring over night .										
POSF 2876 blocked fuel line 1 hour into test.										
POSF 2881 rapid delta P increase. Variable delta P with 2913 & 2912. Insoluble precipitate when blended with 2759 and 2899.										

APPENDIX B: APPB_FIN.XLS

		MTP Tests										Revised 03/26/92		
All Data From All Tests														
POSF		Conc.		Test	50 mL Samples, µg carbon					Filter		std		
No.	Description	(mg/L)	Date	No.	1	2	3	4	5	Avg.	Avg.	dev.		
JP-TS	10 mg/L 2904 +	0	7/24/91	1	1571	1619	1638	1796	1896	1704				
Exxon	23 mg/L 2851 +		8/02/91	2	3632	3670	3755	4109	3790	3791				
	11 mg/l 2786			3	2947	2962	3057	2927	2908	2960	2818	897		
				4	2799	2790	3001			2863	Not Prefiltered			
91-2795	Upper Limit	0	8/09/91	1	3135	2847	2480	3354	3370	3037				
			8/09/91	2	3792	3676	3968	3761	4116	3863	3450	516		
90-2747	Highly Refined	0	8/12/91	1	3133	2918	3119	2888	2879	2987				
			8/14/91	2	5629	5865	5786	5698	6463	5888	4438	1547		
				3	4874									
	N2 Over Pressure	0	9/06/91	1	374	357	344	340		354				
	No Over Pressure	0	9/20/91	1	706	694	709	730	824	733				
90-2786	SOA	11	7/24/91	1		8774	8363	7149	7258	7886				
			8/02/91	2	8827	9236	9943	8800	8996	9160				
			8/12/91	3	7336	7405	7156	7220	7378	7299	8132	956		
	SOA	50	9/20/91	1	9443	8983	8441	10070	9332	9254				
		100	9/24/91	1	8375	7725	5894	6155	6091	6848				
90-2748	Extender/Stabilizer	200		1	10610	10840				10725	Not Prefiltered			
90-2753	N2/O2 Type AO	25		1	7520	9012				8153	Not Prefiltered			
90-2761	N2 AO	25	7/25/91	1	7248	6077	5147	4539	4483	5499				
				2	6304	5977	5327	4750	4716	5415	5457	915		
				3	6774	5838	6500			6371	Not Prefiltered			
90-2726	Det./Disp.	1000		1	8773	6190	4930	5098	15170	Formed Sludge				
90-2776	AO/Det./Disp./	12		1	8382	9227				8805	Not Prefiltered			
91-2827	Additive Free	0	7/23/91	1	8957	8334	7276	7225	7408	7840				
				2	7004	6643	6200	6107	6466	6484	7162	912		
				3	7474	6968				7221	Not Prefiltered			
	N2 Over Pressure	0	9/06/91	1	748	718	762			743				
	No Over Pressure	0	9/23/91	1	372	347	462	350	361	378				
90-2774	AO/Disp./MD	12		1	9838	10260				10049	Not Prefiltered			
90-2744	Det./Disp.	1000		1	14000	13720				13860	Not Prefiltered			
Notes:														
MTP Test Conditions: Prefiltered fuel/Air spraged/300F°/3 HRS./200psi air/No solvent rinse														
Disp. = Dispersant; Det.=Detergent; AO= Antioxidant; MD= Metal Deactivator														

APPENDIX C: APPC_FIN.XLS

FUEL REACTOR TESTS							Revised 4/14/92		
<i>POSF</i>		<i>Conc.</i>	<i>BURN OFF</i>	<i>Test</i>	<i>Carbon</i>	<i>Avg. of</i>			<i>r</i>
<i>No.</i>	<i>Description</i>	<i>(mg/L)</i>	<i>Date</i>	<i>No.</i>	<i>ug</i>	<i>Runs</i>	<i>Range</i>	<i>sd</i>	<i>(sd/x)</i>
91-2799	Upper Limit	0	12/6/91	1	242				
			12/6/91	2	216	229	26	18	
			4/9/92	3	155				
			4/9/92	4	164	160	9	6	
91-2827	Additive Free	0	12/6/91	1	545				
			12/16/91	2	433				
			12/16/91	3	553				
			12/16/91	4	474	501	120	58	
			4/9/92	5	562				
			4/9/92	6	570	566	8	6	
2786in 2747		11	1/16/92	1	250				
			1/16/92	2	242				
			1/16/92	3	258				
			1/16/92	4	242	248	16	8	
90-2747	Highly Processed	0	1/16/92	1	260				
			1/16/92	2	278				
			1/16/92	3	285				
			1/16/92	4	252	269	33	15	
			4/9/92	5	181				
			4/9/92	6	168	175	13	9	
90-2761	N2 Type AO	25	2/7/92	1	496				
			2/7/92	2	398	447	98	69	
			2/7/92	3	551				
			2/7/92	4	483	517	68	48	
90-2786	SOA	11	2/7/92	1	783				
			2/7/92	2	493				
			2/7/92	3	453				
			2/7/92	4	441	543	342	162	
			4/9/92	5	787				
			4/9/92	6	815	801	28	20	
91-2841	N2/O2 AO	25	3/4/92	1	223				
			3/4/92	4	373	298	150	106	
91-9843	O2 AO	25	3/4/92	3	192				
			3/4/92	4	167	180	25	18	
Test Conditions: 6-min. air sparge; 200 psi air; 300F; 3 hrs.; 60 mL sample; COS bath									

APPENDIX C: APPC_FIN.XLS

[illegible]